

BIOGEOCHEMICAL STUDIES OF PHOTOSYNTHETIC MICROBIAL MATS AND THEIR BIOTA.

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Photosynthetic microbial mats offer an opportunity to define holistic functionality at the millimeter scale. At the same time, their biogeochemistry contributes to environmental processes on a planetary scale. These mats are possibly direct descendents of the most ancient biological communities; communities in which oxygenic photosynthesis might have been invented. Mats provide one of the best natural systems to study how microbial populations associate to control dynamic biogeochemical gradients. These are self-sustaining, complete ecosystems in which light energy absorbed over a diel (24 hour) cycle drives the synthesis of spatially-organized, diverse biomass. Tightly-coupled microorganisms in the mat have specialized metabolisms that catalyze transformations of carbon, nitrogen, sulfur, and a host of other elements.

Carbon and oxygen budgets of subtidal and intertidal cyanobacterial mats [1]: Intertidal cyanobacterial mats (*Lyngbya*-dominated) are contrasted with mats (*Microcoleus*-dominated) that grow in subtidal (0.7m water depth) hypersaline (90-110 permil) environments. In benthic chamber experiments conducted in Oct., 1999, *Lyngbya* mats exhibited greater net uptake of dissolved inorganic carbon (DIC) from overlying water during the daylight period than *Microcoleus* mats (e.g., 200 vs 120 mmol C/m at 26 deg C, respectively). Net DIC release at night was similar for both mats (~80 mmol C/m). Daytime net O₂ release by *Lyngbya* mats exceeded that by *Microcoleus* mats (150 vs 100 mmol O₂/m), and O₂ uptake at night was comparable for both mats (60-80 mmol O₂/m). Nonphotosynthetic populations are more prominent within the subtidal versus intertidal mats, and accordingly exhibited greater internal O₂ uptake and DIC production during the day. Over 24 hours, *Lyngbya*-dominated mats exhibited greater net uptake of DIC than subtidal *Microcoleus* mats, consistent with these intertidal mats being "pioneer" communities that constantly recover from periodic physical disruption in energetic environments. The *Microcoleus*-dominated mats achieve steady-state mat thicknesses by balancing primary production against diagenetic decomposition of cellular and extracellular organic constituents.

Sulfate reducing bacteria; carbon isotopic discrimination during heterotrophic and autotrophic growth [2]: Anaerobic sedimentary microbial communities can profoundly influence the isotopic and organic signatures preserved in the fossil record. Accordingly,

we have determined carbon isotope discrimination associated with both heterotrophic (organic carbon-utilizing) and autotrophic (CO₂-utilizing) growth of pure cultures of sulfate-reducing bacteria (SRB). The isotopic composition of cellular constituents and excretion products can reflect biochemical interactions at both intracellular and ecological levels. Therefore, isotopic patterns must be interpreted in the context of kinetic isotope effects that are modulated by networks of enzymatic transformations that compete for key substrates such as acetate. Sealed vessels containing the SRB cultures were harvested at different time intervals, and $\delta^{13}\text{C}$ values were determined for gaseous CO₂, organic substrates, and products such as total cellular carbon. *Desulfobacterium autotrophicum*, which uses the acetyl-coenzyme A pathway for both carbon fixation and acetate catabolism, expressed different isotope discrimination depending upon the carbon source. Grown lithoautotrophically (using H₂ and CO₂) with a large excess of available CO₂, the biomass was depleted by almost 12‰ relative to the CO₂ substrate. Grown heterotrophically on acetate, SRB biomass was only 0 to 2‰ depleted relative to acetate or the final CO₂ pool, whereas the CO₂ released from acetate catabolism was depleted by 7‰, relative to the acetate substrate. In contrast, *Desulfovibrio desulfuricans* grown heterotrophically produced biomass and CO₂ that were about 3‰ lighter than the lactate substrate, and these values did not change significantly as a function of the fraction of lactate consumed. Several preliminary conclusions can be made. Isotopic discrimination associated with autotrophic CO₂ assimilation is significantly larger than with growth using lactate or acetate. Competition for acetate between assimilatory and dissimilatory pathways might affect the relative $\delta^{13}\text{C}$ values of biomass and excreted carbon. Thus, by controlling the availability of carbon substrates (e.g., lactate, acetate and CO₂) and reducing power (e.g., H₂), ecological and other environmental factors can substantially affect carbon isotopic discrimination by SRB.

References:

- [1] Londry K. L. and Des Marais D. J. (1999) Abstracts with Programs, Geological Society of America 1999 Annual Meeting, p. A-489. [2] Des Marais D. J., Discipulo M. and Turk K. (2001) ASLO American Society of Limnology and Oceanography 2001 Aquatic Sciences Meeting, p. 46